DO MOUNTAIN PINE BEETLE OUTBREAKS INCREASE THE RISK OF HIGH-SEVERITY FIRES IN WESTERN FORESTS?

A SUMMARY OF RECENT FIELD STUDIES

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Photo: D. Kulakowski – upper elevation forests in the Rockies showing effects of fire (background) and mountain pine beetle (foreground)

EXECUTIVE SUMMARY – The following summarizes results from dozens of recent field studies from multiple regions (Pacific Northwest, Pacific Southwest, Rockies) and forest types (mixed conifer, mixed evergreen, subalpine, lodgepole pine, spruce-fir) on effects of mountain pine beetle tree kill on fire severity. There is now substantial field-based evidence showing that beetle outbreaks do not contribute to severe fires nor do outbreak areas burn more severely when a fire does occur. Outbreaks are primarily the result of a warming climate that has allowed more beetles to survive and to have multiple broods within a breeding season. In terms of the effects of thinning and logging on beetle outbreaks, the studies show mixed effects on reducing tree mortality before outbreaks at the stand level, no effect during outbreaks of landscape scales, and substantial impacts of post-fire logging on resilience of forests to natural disturbances, including the potential for logging and road building to increase future fire risk and severity. Many studies recommend treating the home-ignition zone, 100-200-ft from a home structure outward, and building with fire-resistant materials as proven fire-risk reduction methods. Focusing

on defensible space, requires treating a narrow zone nearest homes totaling ~12,282 square miles in 13 states. Treating forests in the backcountry, or outside of this zone, is costly and does nothing to stop insect outbreaks, diverting limited resources away from incentivizing and creating defensible space.

BEETLE OUTBREAKS DO NOT CAUSE MORE INTENSE FOREST FIRES

Since the mid 1990s, mountain pine beetles have killed pine trees across some 27,413 square miles[1], an area larger than the state of West Virginia. Such outbreaks have led to widespread concerns that the dead trees left behind by these outbreaks increase the risk of high-severity fire. Recent field studies in western forests have consistently shown that outbreaks actually do little to increase fire severity[2,3].

In sum, the observed effect of beetle outbreaks on severe fires appears to be negligible. This is true for “red-stage stands” (needles fade to red within a year of tree death) to “gray-stage stands” (needles have fallen off and are no longer present within 2-3 years of tree death) during peak years of wildfire activity based on multiple studies[1-7].

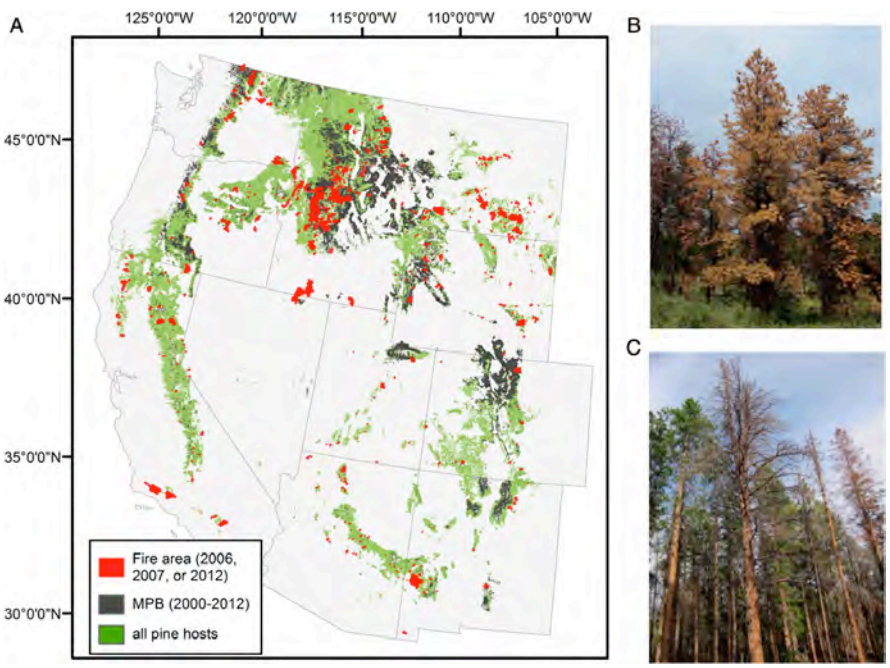

Fig. 1. Major wildland fires in 2006, 2007, and 2012 that intersect mountain pine beetle (MPB) hosts and cumulative MBP infestation in 2000–2013 across the western United States. (A) Extent of all pine hosts of MPBs (green), cumulative 2000–2013 MPB infestation (dark gray), and major wildland fires (>405 ha) that burned in 2006, 2007, or 2012 (red) and intersected MPB hosts (n = 546 fires). The fire area reflects the entire area burned, inclusive of MPB pine hosts and other cover types. Photographs of red-stage MPB infestation in ponderosa pine (B) and gray-stage infestation in lodgepole pine (C) are shown (reprinted[1]).

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[1]Hart, S.J., et al. 2015. Area burned in the western United States is unaffected by recent mountain pine beetle outbreaks. PNAS Early Edition www.pnas.org/cgi/doi/10.1073/pnas.1424037112.
[2]Kulakowski, D. and T. T. Veblen. 2007. Effect of prior disturbances on the extent and severity of wildfire in Colorado subalpine forests. Ecology. 88(3): 759–769. Kulakowski, D. and D. Jarvis. 2011. The influence of mountain pine beetle outbreaks on severe wildfires in northwestern Colorado and southern Wyoming: a look at the past century. Forest Ecology and Management. 261 (1): 1686–1696.
[3]Hart, S.J., et al. 2015. Negative feedbacks on bark beetle outbreaks: widespread and severe spruce beetle infestation restricts subsequent infestation. PLOS ONE | DOI:10.1371/journal.pone.0127975

Relationship Between Fires and Mountain Pine Beetle Outbreaks[1]

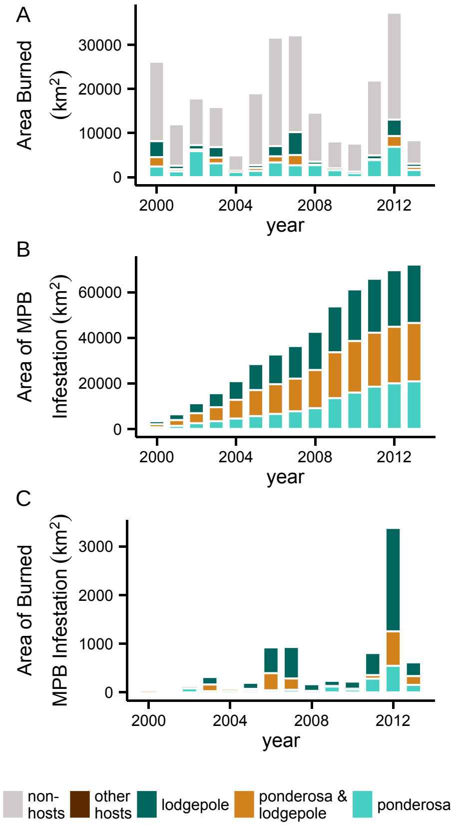

Fig. 2. Annual area burned by wildfires and cumulative area infested by MPBs (2002–2013) across the western United States in primarily ponderosa pine (light green), mixed ponderosa and lodgepole pine (gold), primarily lodgepole pine (dark green), other MPB hosts (dark brown), and non-MPB hosts (light gray). (*A*) Annual area burned, calculated from the MTBS fire perimeter dataset. (*B*) Cumulative area infested by MPBs, determined from US Forest Service ADS data. For each year, ADS polygon data were converted to grids of 990 × 990-m pixels and cross-validated with a corresponding map of the distribution of MPB hosts. (*C*) Annual area burned in the cumulative area infested by MPBs.

There are numerous examples that decouple mountain pine beetle (MPB) outbreaks from forest fires as summarized in Figure 2 and in regional studies below. As Figure 2 depicts, as mountain pine beetle outbreaks increased across the western United States, fires did not track outbreaks and where fires did occur they were by and large were not in the areas affected by mountain pine beetle.

Regional Examples

Rockies - Empirical studies of forest fuel levels immediately following outbreaks and retrospective studies of fires that burned in lodgepole pine and spruce-fir forests throughout the U.S. Rockies that were recently affected by outbreaks suggest that outbreaks may actually **decrease** risk of high-severity fires. This is the case even during and immediately following outbreaks. There is general agreement that **the risk of active high-severity crown fires actually decreases in years to decades following outbreaks** due to reduced forest canopy density (i.e., more dead trees means forest canopies are less dense)[3].

Greater Yellowstone Ecosystem - In upper Douglas-fir forests of Wyoming, pre-fire outbreak severity **did not increase fire severity when fires occurred[4]**. In another study, also in Douglas-fir forests of Greater Yellowstone, beetle outbreaks killed 38-83% of the basal area within forest stands resulting in a reduction in canopy fuel loads and bulk crown density during the red stage that continued into the silver stage[5]. These studies demonstrate that following beetle outbreaks there is actually a **reduction in the**

[3]Kulakowski, D., and T.T. Veblen. 2015. Bark beetles and high-severity fires in Rock Mountain subalpine forests. Pp. 149-178, In D.A. DellaSala and C.T. Hanson. The ecological importance of mixed-severity fires: nature's phoenix. Elsevier, UK.
[4]Harvey, B.J. et al. 2013. Influence of recent bark beetle outbreak on fire severity and postfire tree regeneration in montane Douglas-fir forests. Ecology 94: 2475–2486.
[5]Donato, D.C. 2013. Bark beetle effects on fuel profiles across a range of stand structures in Douglas-fir forests of Greater Yellowstone. Ecol. Applications 23:3-20.

likelihood of subsequent crown fires for decades given reduced forest crown densities and fuels.

Mixed-Evergreen Forests, CA - In mixed-evergreen forests below 5,000 feet in the San Bernardino Mountains of California, pre-fire tree mortality from drought and western pine beetles **did not influence subsequent fire severity** in stands where most pre-fire dead trees had retained needles[6].

These are the results of just a few of the dozens of studies from multiple regions on this topic as reported by the study authors[1-7].

CLIMATE IS THE MAIN DRIVER OF BEETLE OUTBREAKS

Research conducted on beetle outbreaks has consistently shown that **fire-weather and climate are more important factors than effects of outbreaks** in determining fire behavior in western forests[1-5].

Thus, the effect of fires on susceptibility to outbreaks may be contingent on current and future climate influences on beetle populations and tree resistances. Occurrence of large severe bark beetle outbreaks also may deplete tree host populations that then reduce the probability of subsequent outbreaks for 70 years or more[4]. For example, under a weather scenario of future dry climate, reduction of host tree populations may lower the probability of subsequent bark beetle outbreaks in some forest types.

DOES THINNING AND OTHER FORMS OF LOGGING LESSEN BEETLE OUTBREAK RISKS[7]?

(A)

(B)

Photo: (A) Thinning results in piles of logging slash that if not treated increase future fire risks (Greensprings area, Ashland, OR). (B) Post-fire logging often removes the least flammable portion of a burned forest – large live and dead trees – leaving behind substantial logging slash (Biscuit area, southwest, OR; D. DellaSala).

[6]Bond, M.L., et al. 2009. Influence of pre-fire tree mortality on fire severity in conifer forests of the San Bernardino Mountains, California. The Open Forest Science Journal 2:41-47.

[7]Adapted from Black, S.H. et al. 2013. Do bark beetle outbreaks increase wildfire risks in the Central U.S. Rocky Mountains: Implications from Recent Research. Nat. Areas J. 33:59-65.

Before Outbreaks - Thinning to reduce forest susceptibility to bark beetles is believed to be related to improved tree vigor from decreased moisture stress. Reduced moisture stress in turn makes trees less susceptible to insect infestations. The premise is that if the trees are healthy and vigorous, they may be able to "pitch out" attacking beetles, essentially flooding the entrance site with resin that can push out or drown the beetle.

Studies that have looked directly at thinning effects on tree vigor in Douglas-fir and ponderosa pine forests show mixed results[7]. While some researchers have found thinning reduces beetle susceptibility in **forest stands** when there is not an outbreak, others have found that bark beetles do not preferentially infest trees with declining growth. Under some circumstances, thinning may alleviate tree stress at the stand level but does not mitigate susceptibility against extensive or severe outbreaks[7].

Specifically, while thinning can maintain adequate growing space and resources, there is accumulating evidence that suggests tree injury, soil compaction, and temporary stress caused by thinning may increase susceptibility of remaining trees to bark beetles and forest pathogens that invade weakened trees[7]. It is also prudent to consider how such strategies alter normal stand structure. For example, thinning in naturally dense upper elevation Engelmann spruce forests is likely to create artificial conditions reducing resilience of these forests to natural disturbance processes. Thinning in lodgepole pine forests also makes no ecological sense given seed cones of certain populations of this pine open when heated by high-intensity flames.

During Outbreaks - There is general scientific agreement that forest thinning cannot effectively stop outbreaks once a large-scale (landscape) insect infestation has started. Most "control efforts" involving thinning have had little effect on the final size of outbreaks and can do more harm than good[7]. This is because once an extensive outbreak has started, active management is unlikely to stop it as beetles overwhelm host resistance to outbreaks. Thinning large areas also can have major consequences (impacts) to soils, water quality (e.g. from soil runoff), wildlife, recreation, and other forest values[8].

After Outbreaks – Post-disturbance logging is common practice in forests that removes trees or other biomass to produce timber. By reducing habitat for species that specialize by feeding on insects, post-disturbance logging can actually inadvertently lead to greater insect activity. Outbreaks may be prolonged by logging because of a reduction in the beetle's natural enemies, including insects and bird species that feed on mountain pine beetles[8]. Post-disturbance logging also damages soil and roots through compaction, leading to greater water stress in trees, which in turn may reduce natural conifer regeneration by increasing sapling mortality and, in general, may cause extensive damage to forests that are in early stages of post-disturbance response. Further, such logging can elevate future fire risks by removing the least flammable portion of a burned forest – large dead and live trees - and leaving behind substantial logging slash as kindling[8].

[8]For extensive review of post-disturbance logging see DellaSala, D.A. et al. 2015. In the aftermath of fire: logging and related actions degrade mixed- and high-severity burn areas. Pp. 313-347, In DellaSala, D.A., and C.T. Hanson (eds), The ecological importance of mixed-severity fires: nature's phoenix. Elsevier, UK.

Road Building is Ecologically Damaging - A broad scale program to treat forests that have been affected by bark beetle or fires will require an extensive road system, which has significant impacts to forest and aquatic ecosystems[7]. In general, the major results of roads on the terrestrial environment include increases in forest fragmentation and disruption of the natural movement of species across the landscape. Aquatic systems are impacted through disruption of natural infiltration of water into the soil and increased runoff to streams.

These effects are particularly pronounced in mountainous regions, especially on high gradient streams, headwaters, and granitic soils. Increased sediment to streams causes changes to channel morphology and channel substrate detrimental to water quality and aquatic species, particularly cold-water fisheries such as wild salmon. While proper road engineering can help mitigate some negative effects, it does not mitigate the overall impact of roads on hydrologic processes, water flow, and fragmentation of wildlife habitat by roads that act as chronic stressors to ecosystems. Roads also increase human-caused fire ignitions due to greater access during fire season.

ECOSYSTEM BENEFITS OF BARK BEETLE OUTBREAKS

Photo: Complex early seral forests with abundant snags produced by fire and insects are some of the most bio-diverse and rare forest types in western North America (D. Bevington)

Bark beetle outbreaks do not destroy the forest as forests are quite resilient to them, rebounding soon after the outbreak with vigorous plant growth. Bark beetle-caused tree mortality also increases the diversity of plant species by creating gaps in the forest canopy that provide increased sunlight and nutrients for plant growth. Dead trees (snags) caused by outbreaks are the most ecologically valuable structures of a forest, used by numerous woodpeckers, owls, hawks, songbirds, bats, squirrels, and martens. The ensuing "complex early seral forest" (snag forest) is one of the most biologically diverse and rarest forest types in western North America because salvage logging nearly always destroys these forests[8,9].

Beetle-killed trees also contribute to recruitment of large coarse woody debris into riparian areas and streams, which exerts important beneficial influences on storage of sediment and organic matter and river and floodplain habitat for wildlife, including trout. In comparison to logging that can remove all riparian wood and severely deplete instream wood recruitment, beetle outbreaks provide a source of instream wood for decades.

CONCLUSIONS

Climate change and a history of logging in western forests are leading to unprecedented changes to forest ecosystems. Increased bark beetle activity resulting in extensive tree mortality over large areas is a direct consequence of recent and predicted climate change that may actually be exacerbated by increased logging levels as a response. Insect containment measures such as forest thinning have yielded mixed effects at the stand level before outbreaks, no effect at dampening outbreaks in progress, and detrimental effects post-outbreak.

We recommend that priority be given to limited removal of hazardous trees within the immediate road prism and campgrounds to prevent potential loss of life from falling dead trees overtime. Moreover, in order to reduce existing and future risks of fire, it is prudent to concentrate fuel reduction activities within a defensible space of 100-200 foot zone around homes as this method has been shown to be most effective in reducing a home's ignitability (Fig. 3)[10].

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[9]Swanson, M.E., et al. 2011. The forgotten stage of forest succession: early-successional ecosystems on forested sites. Frontiers in Ecol. and Environ. 9:117-125 doi:10.1890/090157. Donato, D.C et al. 2012. Multiple successional pathways precocity in forest development: can some forests be born complex? J. Vegetation Sci. 23: 576-584. DellaSala, D.A., et al. 2014. Complex early forests of the Sierra Nevada: what are they and how can they be managed for ecological integrity? Nat. Areas J. 34:310-324.

[10]Cohen, J.D., 2000. Preventing disaster: home ignitability in the wildland-urban interface. J. For. 98, 15–21. Cohen, J.D., 2004. Relating flame radiation to home ignition using modeling and experimental crown fires. Can. J. For. Resour. 34:1616–1626. Syphard, A.D., et al. 2012. Housing arrangement and location determine the likelihood of housing loss due to wildfire. PLoS One 7, e33954. Syphard, A.D., et al. 2014. The role of defensible space for residential structure protection during wildfires. Int. J. Wildland Fire 23: 1165–1175.

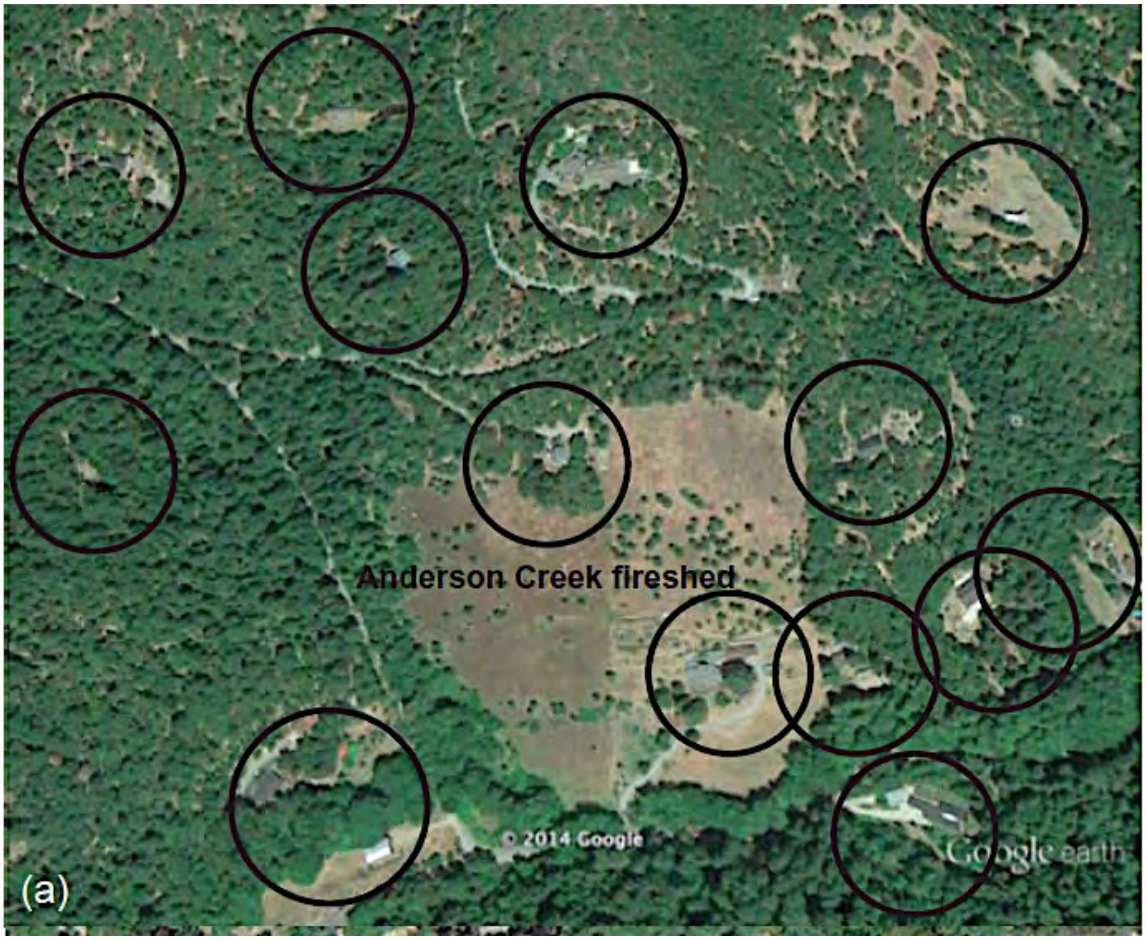

Fig. 3. Google Earth image of the Anderson Creek watershed (southwest Oregon) and community fireshed showing a housing development. Circled areas depict where proper fire risk reduction has the greatest chance of saving homes in a fire[11].

Treating home areas would be more effective and less expensive than treating remote beetle-affected forests[12]. This approach would involve a substantial commitment and re-prioritization of fuels reduction efforts nearest homes and conducted in partnership with private landowners and the States (Table 1).

[11]DellaSala, D.A., et al. 2015. Flight of the phoenix: coexisting with mixed-severity fires. Pp. 372-396, In DellaSala, D.A., and C.T. Hanson (eds), The ecological importance of mixed-severity fires: nature's phoenix. Elsevier, UK.

[12]Aronson, G., and D. Kulakowski. 2012. Bark beetle outbreaks, wildfires and defensible space: how much area do we need to treat to protect homes and communities. Int. J. Wildland Fire. http://dx.doi.org/10.1071/WF11070

Table 1. Estimated maximum defensible space by state using a 130-ft home ignition zone around housing units in the wildland-urban interface[12].

State	Treated Area	State	Treated Area
Arizona	1288	New Mexico	416
California	4538	Oregon	860
Colorado	929	South Dakota	109
Idaho	325	Utah	485
Montana	348	Washington	1856
Nebraska	105	Wyoming	202
Nevada	821	**Totals**	**12,282**

Since beetle outbreaks and fires are both linked to global warming, prudent policies first and foremost would focus rapidly reducing greenhouse gas emissions rather than having a preoccupation with the effect of warming – outbreaks and fires. Logging to contain outbreaks or fire events simply does not work, is an expensive and ineffective use of tax-payer resources, and comes with significant costs to ecosystems that are otherwise quite resilient to natural disturbance events[13].

[13]D.A. DellaSala and C.T. Hanson (eds). 2015. The ecological importance of mixed-severity fires: nature's phoenix. Elsevier, Boston.